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VEGETATION RECOVERING...
little erosion on Hanalei watershed after fire

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ABSTRACT: After a fire burned the Hanalei watershed on Kauai, Hawaii, transects and vegetation plots were established to record surface conditions and recovering vegetation. Four months after the fire, 86 percent of the transect length had a vegetation cover of less than 50 percent. Six months later, 94 percent of the transect length had a vegetation density of greater than 50 percent. Among the recovering herbaceous vegetation, fireweed was the dominant species. Uluhe regeneration has been low. Eight months after the fire, koa seedlings had a survival rate of 78 percent. Aerially seeded grasses and legumes were well established. No evidence of widespread erosion was found.

RETRIEVAL TERMS: Hawaii; Hanalei watershed; post-fire vegetation; burn recovery; *Eucalyptus* spp.; *Acacia koa; Dicranopteris linearis; Erechtites hieracifolia.*

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In Hawaii, a forest fire is news—especially so when it occurs at the site of a major tourist attraction. Hanalei Valley, one of the most photographed spots on the island of Kauai, is such an attraction. On June 18, 1967, a wildfire swept Hanalei watershed, blackening the scenic backdrop of the valley. It took several days to contain the fire at 3,000 acres. Most of the scattered trees on the watershed appeared dead. The tangled, dense ground cover of uluhe fern *(Dicranopteris linearis),* lantana *(Lantana camara),* and other shrubs had been consumed *(fig. 1).*

The Hawaii Division of Forestry in concert with concerned local, State, and Federal agencies immediately began planning for rehabilitation. Improving the soil-protecting cover on the steep, rugged watershed slopes was considered the highest priority. High intensity storms might occur at any time and could be expected with the onset of winter.

Several long-range goals were also recognized. If the dense uluhe fern—a fire hazard during dry spells—could be kept off the slopes, future fire potential would be reduced. Furthermore, with a less dense ground cover, the land would have a much greater recreation value. Wildlife habitat would be improved. And the scenic backdrop would be restored.

But what was needed in the way of rehabilitation effort? It became apparent that no one could assure that the rate and kind of natural vegetation succession would be adequate for either the immediate or long-range goals. Therefore, because of the need for a protective cover of vegetation, the Hawaii Division of Forestry aerially seeded grasses and legumes on 1,500 acres of heavy burn. Seeds of saligna eucalyptus *(Eucalyptus saligna),* blackbutt eucalyptus *(E. pilularis),* and Molucca albizzia *(Albizia falcata)* were included on a few selected strips. Seedlings of saligna

and blackbutt eucalyptus were hand planted on some 325 acres.

To study the effects of wild fire on vegetation and the consequent impact on watershed values, we set up sample line-transects and vegetation plots in September 1967. We did not attempt to sample the entire burn, but located our transects so as to sample a major portion of it. Repeat measurements were made in April 1968; observations will be continued for several years.

From the first two series of measurements, we found that densities of recovering vegetation along the transects rose dramatically between the two observations. No evidence of erosion was found on the burned slopes.

Observations

Transects: More than 2 miles of transects were established in the burn. Soil surface condition, slope, aspect, elevation, and vegetation type (where present) were recorded as intercepts along alternate 100 foot transect sections, 5,700 feet in all. Vegetation density was estimated for each intercept unit along the transect. Species present in the area immediately next to the transect were recorded. Existing surface conditions were coded and recorded as follows:

01: Bare soil
02: Burned with only burned stubble remaining
03: Pre-fire vegetation killed by heat but unburned
04: Pre-fire vegetation undamaged by the fire
06: Burned, but with unburned litter remaining on the surface.

Along the transects, 25 percent of the surface length had essentially all of the soil-protecting plants and litter consumed by the fire. Another 60 percent had unburned litter present either in a complete mat or with small interspersed spots of complete burn *(fig. 2).* Six percent was classed as bare soil, and about half of this amount was encountered as road cuts. And on the remaining 9 percent, unconsumed vegetation was found, with nearly equal amounts in the dead but unburned class and in the undamaged class.

Percent of slope had some influence on post-fire surface conditions. As the percent of slope increased, the proportion of surface with no unburned litter also increased. This relationship presumably indicates that the steeper the slope, the hotter the burn. Within the area sampled, neither elevation nor aspect appeared to have affected the post-fire surface condition.

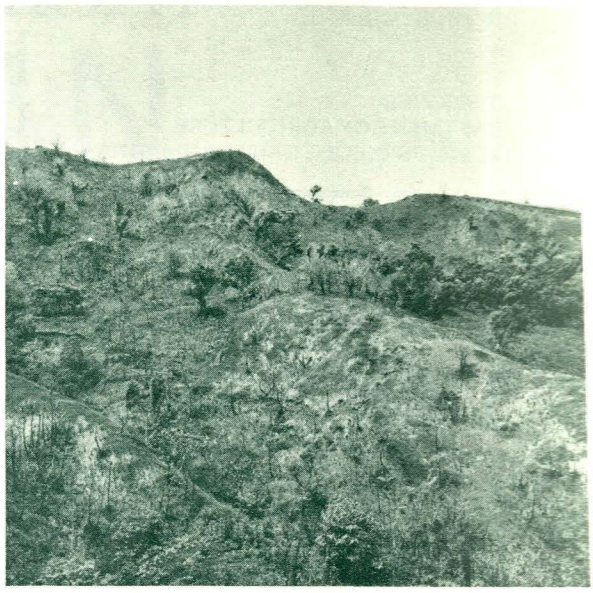

Figure 1.–*This portion of Hanalei watershed after the fire of June 18, 1967, was typical of entire burn.*

We listed the species found along the transects, but based vegetation densities on a composite figure for all species. By "density," we mean the percent of the ground surface under living plant cover. Three broad density classes were used: (a) less than 10 percent, (b) 10–50 percent, and (c) greater than 50 percent.

Figure 2.–*Surface conditions of the burned watershed was recorded:* left, *burned with only burned stubble present;* right, *burned, but with unburned litter remaining on the surface.*

these effects is unknown, but will presumably decrease with time. In a study comparing runoff from a burned uluhe-covered watershed for about 2 years before and after burning, Anderson, *et al.*[4] found that the relation between storm rainfall and total storm runoff was only slightly affected by burning. After the fire, peak storm discharges were much more variable, presumably because of changes in surface roughness and detention characteristics. But runoff from the fern watershed both before and after burning was greater than from an adjacent tree-covered watershed. The value of uluhe fern solely as a watershed cover obviously needs further study.

- The place of koa in the ultimate post-fire vegetation cannot yet be determined. The number of mature trees will probably be much less than the seedlings found to date. The survival and growth (up to 15 feet in less than a year) of the planted eucalypts indicate that this area may have potential as a recreation forest of mixed native and introduced trees. And the need for such areas is bound to increase with the continuing growth of tourism in the Hanalei area.
- The aerially seeded herbaceous species have not yet made sufficient growth to evaluate their final effectiveness as soil protecting cover.

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Notes

[1]Hosaka, E. Y., and Thistle, A. *Noxious plants of the Hawaiian Ranges.* Univ. Hawaii Ext. Bull. 62. 39 p. 1954.

[2]Whitesell, Craig D. *Silvical characteristics of koa (Acacia koa Gray).* U.S. Forest Serv. Res. Paper PSW-16, Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 12 p. 1964.

[3]Motooka, P. S.; Plucknett, D. F.; Saiki, D. F.; and Younge, O. R. *Pasture establishment in tropical brushlands by aerial herbicide and seeding treatments on Kauai.* Hawaii Agr. Exp. Sta. Tech. Progress Rep. 165. 18 p. 1967.

[4]Anderson, Henry W.; Duffy, Paul D.; and Yamamoto, Teruo. *Rainfall and streamflow from small tree-covered and fern-covered and burned watersheds in Hawaii.* U.S. Forest Serv. Res. Paper PSW-34, Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 10 p., illus. 1966.

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Lantana, considered a noxious plant and of little value to a watershed,[1] was also one of the dominant recovering species. We found lantana in 22 of the burned plots in September, and in 26 of the plots in April. Densities were low but, unlike fireweed, the lantana will likely become more persistent.

Uluhe, or false staghorn fern, is a major unknown factor in the study. Hopefully, uluhe will not become re-established to its former densities, thus preventing ready access to the watershed with an impenetrable dense covering and providing the fuel potential for another fire. Four months after the fire, we found uluhe regrowth on only one vegetation plot; 10 months after the fire, four plots had uluhe regrowth on them in low densities.

Strawberry guava *(Psidium cattleianum)* plants found on the plots were largely unkilled by the fire—even when the crown was burned. Some live crown or stem sprouts were in evidence by September on 10 of the 11 guavas identified. Guava seedlings were found on six plots in September and on 14 plots in April.

Seedlings of koa *(Acacia koa)* were found on 32 of the 52 plots in September. By April, 35 plots held koa seedlings. Koa typically germinates readily and in great numbers after a fire, but quickly begins to die off.[2] Initially, koa seedlings on the plots were in relatively high numbers, but by April, even though the number of plots increased, over-all density fell sharply.

We also measured koa regeneration on the five plots on which koa trees, all of which had been fire killed, were found. Koa seedlings were counted on 1-square foot quadrats taken both beneath and beyond the canopy, in the four cardinal directions from the base of each tree. In September, 123 seedlings were counted; in April, only 96 were counted, for a net survival rate of 78 percent. Of the 35 quadrats under the canopy, koa seedlings were counted on 23 in September and on 25 in April. Seedlings per square foot under the canopies averaged 2.4 and 1.5 for the two dates.

Paper-bark *(Melaleuca leucadendron)* seedlings were found on only three plots in September. By April, seedlings were found on 20 plots, one of which had more than 50 seedlings.

Molucca albizzia *(Albizia falcata)* seedlings were recorded on five plots in April. None had been recorded in September, but there may have been a few present which were not recognized as such and were recorded as koa seedlings.

Not enough pandanus *(Pandanus odoratissimus)*, Java plum *(Eugenia cumini)*, and treefern *(Cibotium splendens)* plants were present on the plots to warrant a detailed breakdown. The 17 pandanus trees were dead, the four Java plum trees were sprouting, and most of the treefern had new growth in April. Melastoma *(Melastoma malabathricum)* was found on only one plot in the April survey. Grasses and other herbaceous plants were found on the plots in small numbers.

Seeded, Planted Species: Aerial seeding and fertilizing of portions of the burn were completed in December 1967. Green panicgrass *(Panicum maximum* var. *trichoglome)*, stylo *(Stylosanthes gracilis)*, and loto*(Lotononisbainesii)* were the primary species seeded. Saligna and blackbutt eucalyptus and molucca albizzia seed were also aerially broadcast on small portions of the burn not sampled by our transects or plots.

The aerial seeding covered areas in which 52 of our plots were located (loto was included in the seed mix applied to only 44 of the 52 plots). In April, 27 of the 52 plots contained at least one of the seeded species. Most of those plots had more than 25 plants per plot.

In September, we found 14 live and two dead hand-planted saligna seedlings on eight plots. In April, after additional planting, saligna seedlings were recorded on 18 of the vegetation plots, for a total of 30 live and three dead seedlings.

Erosion Pins: Twenty-two painted "washer and nail" erosion pins were set on transects throughout the burn. Generally, pins were established only on completely burned steep slopes that we considered to have a high erosion potential. We found no evidence from the erosion pins or from general observations that soil movement was a problem. The only indication of erosion was on a recent road cut in which five of the pins had been set.

Conclusions

Several preliminary conclusions can be drawn at this stage of our study.

- Fireweed was the dominant early invader of the Hanalei burn, as is often true of this species after fires elsewhere.[3] An annual herb, it is not considered a prominent part of the natural unburned vegetation. But its presence in large numbers soon after a fire offers some early protective cover.
- Uluhe fern, generally an undesirable plant, appears to have been nearly totally killed by fire. But even when consumed to ground level, the underground rootstocks and stem bases may help prevent soil movement. Patches of unburned uluhe litter provide additional soil protection. The duration of

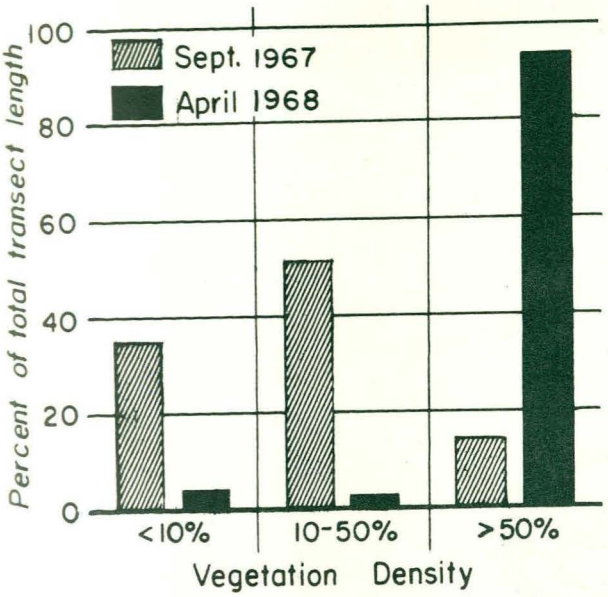

Figure 3.–*Changes in vegetation density of line transects, by date of measurement, Hanalei watershed.*

Dramatic changes occurred in over-all recovering vegetation densities between the September and April observations *(fig. 3)*. In September, 86 percent of the total transect length had a cover density of less than 50 percent; 35 percent was in a cover density class of less than 10 percent. By April, 10 months after the fire and 4 months after aerial seeding, nearly the entire transect length had a cover density exceeding 50 percent. Although the aerially seeded species were common in April, they did not contribute materially to the cover density.

Slope, aspect, and elevation have not had a noticeable effect on the density of the recovering vegetation. There appears to be no difference in the pattern of revegetation on areas of complete burn or where unburned litter remained, except where the unburned mat of litter was more than a few inches thick.

Vegetation Plots: Fifty-seven permanent, circular 1/100-acre vegetation plots also were established after the fire, one at the end of each 100-foot measured transect. Fifty-two of these plots had been entirely burned in the fire. Trees present before the fire were recorded as to species (when possible), condition, d.b.h., height, and crown diameter. Herbaceous and shrub species and the aerially seeded and hand planted trees were recorded as to species, and their number was counted or estimated. Forty-seven species were identified. Plot location, elevation, aspect, and slope were also recorded.

Naturally Occurring Species: Only seven of the naturally occurring species found on the study plots were considered particularly important from their prevalence, desirability, or undesirability *(table 1)*.

The most predominant recovering species was fireweed *(Erechtites hieracifolia)*. In September, 49 of the 52 completely burned plots contained this plant. By April, the number of plots with fireweed increased only slightly, but those with more than 50 fireweed plants nearly quadrupled. By then, the fireweed appeared to be well into its third generation. But this species will probably decrease in numbers in the next few years as other species become more dense.

Table 1.–*Stocking level of vegetation plots on two sampling dates, by selected species*

Species	September 1967			April 1968		
	< 50 plants per plot	> 50 plants per plot	Total	< 50 plants per plot	> 50 plants per plot	Total
	Number			*Number*		
Fireweed	37	12	49	11	41	52
Lantana	22	0	22	25	1	26
Uluhe	1	0	1	4	0	4
Guava	4	2	6	11	3	14
Koa	23	9	32	30	5	35
Paper-bark	3	0	3	19	1	20
Molucca albizzia	0	0	0	5	0	5

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